schizogony in the intestine of the bug. According to Chagas, the true infective cycle of the parasite in the bug is comprised in four stages:—(1) the encapsuled "zygotes"; (2) the schizogony-forms; (3) the trypaniform individuals in the body-cavity; and (4) the similar forms in the salivary glands. I feel it incumbent upon me to state that in my opinion the encapsuled forms are merely resting stages of rounded or crithidial forms, the interpretation of which as zygotes is a pure assumption, and that the so-called schizogony-forms have nothing at all to do with the life-cycle of Schizotrypanum, but appear to be merely parasitic organisms of the nature of yeasts from the intestine of the insect. In justice to the author, however, it should be mentioned that he does not regard his observations on the life-cycle in the invertebrate as in any way final, and considers that many points remain to be further investigated.

The memoir of Chagas contains a great number of very interesting observations to which space does not

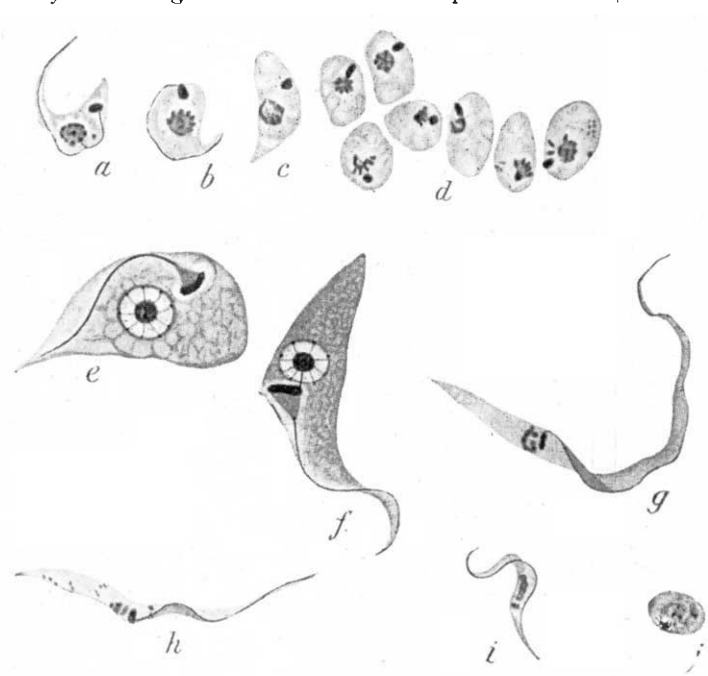

FIG. 3.—*a-j*, Phases of *Schizotrypanum cruzi* in the bug, *Concrhinus megistus*. *a*, *b* and *c*, forms transitional from the ordinary trypanosomes to the rounded forms; *d*, clump of rounded forms; *e* and *f*, change of rounded into crithidial forms; *g* and *h*, crithidial forms; *i*, trypaniform type from the salivary glands; *j*, encapsuled form from intestine.

permit of further reference. We may direct attention especially to his experiments on the variations in the virulence of the parasite as the result of passage through different vertebrate hosts. The whole work is an exceedingly important contribution to our knowledge of the trypanosomes, and we desire to congratulate both the author and the Instituto Oswaldo Cruz on a great achievement. E. A. MINCHIN.

TIDAL RESEARCHES.[1]

THE collection of data as to high and low water at various ports and the investigation of tidal currents present arduous tasks, and amongst those who have devoted themselves to these subjects Dr. J. P. van der Stok occupies a distinguished position. It is due to him that our knowledge of the tides of the Dutch East Indies rivals that furnished by our own admirable survey of India. He is an ardent adherent of the harmonic notation, and in the paper of which we now give an account he tabulates the principal tidal constants for no fewer than 138 ports in the Dutch Indies. To the best of my belief this immense mass of data has been collected and reduced through his own personal initiative.

This pamphlet gives an account of the theory on which harmonic analysis is based, but it is to be regretted, at least by all but his own fellow-countrymen, that it should have been written in his own language. Of course, the language is immaterial as regards the tables of constants, but it may prove an obstacle to those who desire to understand the other interesting points treated by the author.

Dr. van der Stok summarises his results in the form of co-tidal charts for the tract of ocean extending from the Malay Peninsula to New Guinea. The first of these exhibits the march of the principal lunar semidiurnal tide M_2. It appears that there is a point towards the south-eastern end of Sumatra at which the wave divides, one portion travelling north-west and the other eastward along the south coast of Java. Along the north-eastern coast of Sumatra, past Singapore, the wave travels in the opposite direction, namely, towards the south-east. It is met by a wave which travels westward and south-westward along the southern and northern coasts of Borneo, and westward along the northern coast of Java. Thus, in contrast with the divergence of the tide-wave off the south of Sumatra, there is a convergence from all sides towards a point midway between Sumatra and Borneo. Eastward of Borneo, in the direction of New Guinea, the general trend of the wave is northward.

The second of these co-tidal charts is, I believe, unique in that it exhibits the progress of the diurnal tide K_1.[1] The path of this wave exhibits a considerable resemblance to that pursued by the semidiurnal wave, but it differs in the fact that it seems to approach the south coast of Java from the south, and thus the line of advance is from the south throughout the whole tract extending from the southern extremity of Sumatra to New Guinea.

I do not think that any previous investigator has attempted to draw a diurnal co-tidal chart. In the north Atlantic the diurnal tide is insignificant in amount and imperfectly known, but I think it might be possible to construct a similar chart for the coasts of India; I am not aware, however, that any such attempt has ever been made.

At the present time there are only three tide-predicting instruments in existence, namely, those in England, France, and the United States; but I have reason to know that a fourth is being constructed for another Government. Without the aid of such an instrument, tidal prediction is notoriously very laborious, and any process which may render predictions easier is very welcome. I have myself shown how numerical predictions may be made, but the preliminary computations are very laborious and tedious, although when the requisite tables are once formed it is easy and short to make a prediction.[2] But this method does little to facilitate the computation of a tide curve for a given place and given day direct from the harmonic constants. Now Dr. van der Stok pro-

[1] "Elementaire Theorie der Getijden—Getij-Constanten in den Indische Archipel." (K. Nederlandsch Meteorologisch Instituut, No. 102, 1910.)

[1] There is a short discussion of the diurnal tides in Harris's "Manual of Tides," part iv. A, p. 660.

[2] Phil. Trans., clxxxii. A, p. 169, or vol. i. of my "Scientific Papers."

vides just what is wanted to meet this requirement with all needful accuracy. He has computed a set of auxiliary tables from which the required results may be extracted with a fair degree of rapidity. It is in the explanation of the use of these tables that I fear the Dutch language may prove a difficulty to some would-be users of the method.[1]

I shall not try to explain the process in detail, but will only sketch the ideas on which it is founded. It is assumed that sufficient accuracy will be obtained if the phase of each of the constituent tides is specified to the nearest exact hour of mean solar time. It is easy to compute the fall and rise of any constituent tide for successive hours. For example, suppose that we consider the tide M_2, that its amplitude is, say, 174 (expressed in cm. or any other unit), and that we designate the hour of its high water as o h.; then its march would run thus:—

h.		h	
o	... 174	3	... 9
1	... 152	4	... −76
2	... 92	&c.	&c.

Now if at any given place, and on any given day, we find the incidence of the high water of M_2 to the nearest clock hour, it is easy to write down the successive heights from the table in a schedule numbered from o h. to 23 h. If, for example, high water of M_2 is found to occur at 13 h. of clock time on the day in question, we should write 174 opposite 13 h., 152 opposite 14 h., and so on. The same process may be carried out for each of the principal component tides, and the sum may be obtained for each hour of the twenty-four, thus furnishing the resultant height of water. Auxiliary tables are furnished by Dr. van der Stok from which it is easy to determine the incidence of each partial high water in clock time, and tables of fall and rise are given for any required amplitude.

I should guess that it would take from twenty minutes to half an hour to compute and draw a fairly accurate tide-curve for any given day. If this estimate is correct, it would take a computer a month to draw a tide-curve for a whole year. Probably the work would be quicker when the tide is to be found for a succession of days, and in any case the task would not seem to be prohibitive to compute a year's tide-table with accuracy sufficient for practical purposes.

The paper also gives an example of the synthesis from harmonic constants of the tidal currents at a place called Sembilangan. This last statement may well prove almost unintelligible even to a man versed in tidal work. For a full explanation I must refer the reader to Dr. van der Stok's "Études des Phénomènes de Marée sur les Côtes Néerlandaises."[2] Four of this series of papers have been already published by the Nederlandsch Meteorologisch Instituut. I have not seen the first, but the second and third are dated 1905, while the last is of later date than the paper which we are now reviewing. I gather that the first of the series gives a method of obtaining tidal constants from observations taken every six hours, and the subject is resumed in the last paper, which contains an immense mass of information about the constants along the whole length of the Dutch coast. But I must revert to the subject of tidal currents discussed in the second and third of the series, and explain in outline what is meant by the harmonic analysis of tidal currents.

[1] Something of the kind has been done by Harris in his "Manual of Tides," part iii., p. 183. His procedure seems to be more elaborate, and probably more accurate, but also less rapid than that devised by Dr. van der Stok.

[2] These papers ought to have been noticed in the article "Bewegung der Hydrosphäre" of the German Encyclopædia of Mathematics. My article was really written before the publication of Dr. van der Stok's first three papers, but in the subsequent and final revision for the press I carelessly took these papers merely to relate to local hydrography. References are given in them to other papers by MM. Phaff, Petit, van Heerdt, &c., on the hydrography of the Dutch coast.

The author caused a large number of observations to be made from light-ships off the Dutch coast, and then undertook to make an elaborate study of the tidal currents which had been noted. He found it possible to define the velocities and phases of the components of current by means of a notation analogous to that used in defining the rise and fall of the tide. Thus the velocities for the several kinds of tide were specified in centimetres per second, and the phases by angles analogous to the κ's in use in the more ordinary harmonic analysis. A similar investigation had been carried out at Sembilangan, in the Dutch Indies, and it is the result for that place which is given in the paper under review.

It is clear that the harmonic constants which define the horizontal motion of the water cannot claim a high degree of accuracy, but it affords a conspicuous advance that the attempt should have been made and crowned with a certain amount of success.

The vortices off the Dutch coast are very complicated, and the author refers to Airy's theory ("Tides and Waves," §§ 358–63) as affording in some measure an explanation of the facts, although he does not find the explanation by any means complete.

In No. ii. of the papers to which I now refer, Dr. van der Stok integrates, for the light-ship station of Schouwenbank, the expressions for the components of velocity, and thus finds the trajectories of a particle of water under the influences of the tides M_2, S_2, and M_4; he also determines the general drift of the water. The figures illustrative of his conclusions are very interesting, and I commend these papers to the notice of all who are interested in tidal theory.[1]

G. H. DARWIN.

[1] Similar results will be found in Helland-Hansen and Nansen's "Norwegian Sea, Report on Norwegian Fishery," vol. ii., 1909, No. 2, p. 107; and Miss Kirstine Smith's "Gezeitenstroemern," Havundersögelser, vol. ii., No. 13, 1910.

THE LEANING TOWER OF PISA.

THE first stone of the campanile of Pisa was laid in August, 1174, by Bonanno of Pisa and William of Innsbruck, but accounts given us by various authors are very conflicting and uncertain in regard to the construction of this splendid work of art, which, after being interrupted several times, was completed nearly two centuries later.

The tower, which is entirely of white marble, is of cylindrical shape, hollow in the centre, with a spiral staircase constructed in the thickness of the outer wall which leads up to the belfry floor. The first tier is surrounded by fifteen large columns, with vaulted arches half-encased in the wall, and the six upper tiers are each decorated by an equal number of peristyles with arches, supported by altogether 192 isolated columns. The eighth and last tier, of smaller diameter, on which are placed the bells, was constructed, according to tradition, by one Tommaso, architect and sculptor, a pupil of Andrea Pisano.

As is commonly known, the tower, the height of which is about 56 metres, has a noticeable leaning on its axis, and the cause of this leaning gave rise to bitter controversy among the Pisan writers in past centuries, some of whom attributed the strange piece of architecture to the high ingenuity of the builders, while others more reasonably maintained that the explanation was to be sought in the instability of the Pisa subsoil.

The recent investigations of a competent Government Commission, composed of Profs. Mario Canavari, Paolo Pizzetti, and Agenore Socini, and Drs. Giovanni Cuppari and Francesco Bernieri, have not only confirmed that the leaning of the tower is certainly due to a subsidence of the ground, but that this